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WILDLIFE CONSERVATION AND BIODIVERSITY SECTION

Distribution and Habitat Associations of the Long-toed Salamander (*Ambystoma macrodactylum*) in the Oldman River Drainage

Alberta Species at Risk Report No. 75

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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Kim Pearson

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TABLE OF CONTENTS

Acknowledgements..... iii

Executive Summary..... iv

1.0 Introduction..... 1

2.0 Study Area..... 2

3.0 Methods..... 4

4.0 Results..... 7

5.0 Discussion and Recommendations..... 11

6.0 Literature Cited..... 14

Appendix A..... 17

LIST OF FIGURES

Figure 1. Known distribution of *A. macrodactylum* in North America (map designed by M. Thompson, University of Calgary)..... 1

Figure 2. Approximate location and years that long-toed salamander surveys took place within the Oldman River drainage, 1993-2002..... 3

Figure 3. The distribution of long-toed salamanders in southwest Alberta, 1993-2002.... 7

Figure 4. The relative distribution of long-toed salamanders and fish species (trout and/or minnows) in the Waterton and Castle River drainages, 2002..... 8

Figure 5. Mean (± s.e.) proportion survival of larval long-toed salamanders reared for 8 weeks in experimental ponds containing dragonfly larvae, minnows, and .....trout..... 10

Figure 6. Mean (± s.e.) biomass of larval long-toed salamanders reared for 8 weeks in experimental ponds containing dragonfly larvae, minnows, and trout..... ..10

LIST OF TABLES

Table 1. Long-toed salamander surveys within the Oldman River drainage, 1993-2002..... 4

Table 2. Number of sites where long-toed salamanders, trout and minnows were observed in the Waterton and Castle River drainages, 2001-2002..... 9

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EXECUTIVE SUMMARY

Long-toed salamanders are designated as S*ensitive* in Alberta due to their occurrence in patchy, isolated populations, and their vulnerability to habitat destruction or alteration. Three long-toed salamander breeding populations have been identified within the Oldman River drainage: Waterton Lakes National Park, Castle River and Crowsnest. Seven independent long-toed salamander presence/absence surveys occurred in those areas between 1993 and 2002.

Numerous field and experimental studies in Western North America have documented long-toed salamander population declines or extirpations due to the presence of non-native trout. In Alberta, stocking of non-native trout into mountain lakes has been a common practice since the early 1900's. Anecdotal evidence indicates that long-toed salamanders and fish rarely co-exist in southwest Alberta waterbodies.

The objectives of this study were: 1) to increase knowledge of the distribution of long-toed salamanders in southwest Alberta, 2) to merge data derived from seven independent amphibian surveys in southwest Alberta, and 3) to characterize habitat/occurrence associations for long-toed salamanders in southwest Alberta, focusing on their distribution relative to introduced fishes. Results of a simulated pond experiment that examined the effects of various predators on long-toed salamanders are also presented.

Forty-two lakes and ponds were examined for presence/no detection of long-toed salamanders and fish in 2002. Occurrence data collected during other surveys were derived from related reports. Long-toed salamanders were detected at 68 of 135 sites surveyed 1993-2002, at elevations from 1275 m to 2018 m. Thirteen previously unrecorded long-toed salamander breeding locations were documented in 2002. As has been observed in Montana, Idaho and Washington State, trout and long-toed salamanders do not co-exist in wetlands in the Castle and Waterton River drainages. Of the 31 wetlands where long-toed salamanders were observed, 100% lacked trout and 94% lacked minnows.

Experimental ponds are commonly used to evaluate variation in amphibian life histories due to predation and competition. The effects of three predators (rainbow trout fry, fathead minnows, and dragonfly larvae) on the survival and growth rate of larval long-toed salamanders were evaluated in a series of 1200 L plastic tanks at the University of Lethbridge. On average, fewer than 10% of larval salamanders survived 30 days in the trout and minnow ponds, whereas between 25-60% of the larvae in control and dragonfly ponds survived. Exposure to minnows reduced the mass of larvae by 34-50% compared to larvae from the other three environments.

Results of this ongoing project provide improved understanding of long-toed salamander habitat requirements in southwest Alberta, specifically the effects of non-native fishes on long-toed salamanders. Recommendations include continued long-toed salamander surveys, environmental monitoring, aquatic habitat restoration, and effective management of non-native species.

1.0 INTRODUCTION

Throughout their range (Figure 1), long-toed salamanders (*Ambystoma macrodactylum*) are known to inhabit a variety of terrestrial habitat types in proximity to suitable aquatic breeding habitats (Graham and Powell, 1999). Eight long-toed salamander breeding areas have been identified within Alberta, including three within the Oldman River drainage: Waterton Lakes National Park, Castle River and Crowsnest (Powell *et. al.*, 1997). Seven independent long-toed salamander surveys occurred in those areas between 1993 and 2002.

Figure 1. Known distribution of *A. macrodactylum* in North America (map designed by M. Thompson, University of Calgary).

Long-toed salamanders are designated as S*ensitive* in Alberta due to their occurrence in patchy, isolated populations, and their vulnerability to habitat destruction or alteration (ASRD, 2000). The species is typically the top vertebrate predator in fishless lakes and ponds throughout its range.

One of the foremost current threats to global amphibian diversity is the presence of non-native species in amphibian breeding habitats (Alford and Richards, 1999). Numerous field studies in Western North America have identified amphibian populations, those of long-toed salamanders in particular, that have experienced declines or extirpations due to the introduction of non-native trout (Bradford, 1989; Bradford and Graber, 1993; Tyler *et. al.*, 1998; Funk and Dunlap, 1999;

Matthews *et. al.*, 2001; Pilliod and Peterson, 2001). Several experimental investigations have also described negative effects of introduced fishes on various amphibian species (Tyler *et. al.*, 1998b; Figiel, Jr. and Semlitsch, 1990). Further, preference studies show that reproductive amphibians avoid calling and ovipositing in waterbodies containing fish predators (Kats and Sih, 1992; Resetarits Jr. and Wilbur, 1991).

In Alberta, stocking of non-native trout into mountain lakes has been a common practice since the early 1900's (Donald, 1987). At least one documented long-toed salamander extirpation has occurred in Banff National Park due to the introduction of non-native trout (Holroyd and Van Tighem, 1983). Anecdotal evidence for southwest Alberta indicates that long-toed salamanders and fish rarely co-exist in that region (Pearson, unpubl. observ.). Evidence for the negative effects of introduced species on amphibians in Western Canada is primarily anecdotal and to date, the appropriate tests have not been completed.

The objectives of this study were:

- To increase knowledge of the distribution of long-toed salamanders in southwest Alberta.
- To merge data derived from seven independent amphibian surveys in southwest Alberta and produce a current long-toed salamander distribution map for the Oldman River drainage.
- To characterize habitat/occurrence associations for long-toed salamanders in southwest Alberta, focusing on the distribution of long-toed salamanders in relation to the presence of introduced fishes.

The field components of this project are complimented by experimental work conducted under controlled conditions at the University of Lethbridge. Results of that work are described briefly in this document.

This ongoing project will result in a summary of the distribution of long-toed salamanders in southwest Alberta, increased knowledge of where long-toed salamanders do and do not exist in the region, and provide enhanced scientific understanding of the species' habitat requirements. Finally, our understanding of the effects of non-native fishes on long-toed salamanders in southern Alberta will be improved.

2.0 STUDY AREA

The 2002 study area was defined on the west by the Alberta/British Columbia border, on the south by the Canada/U.S.A. border, on the east by Highway 6, and on the north by Highway 3. Surveys were completed at aquatic habitats (lakes and ponds) located within Waterton Lakes National Park (WLNP), the Bow-Crow Forest Reserve, and on privately owned properties. This area and portions of it were included in previous surveys described by Fukumoto (1995), Oseen *et. al.* (1995), Nelson *et. al.* (1995), Wallis *et. al.* (2002), Paton (2002) and Pearson (2001). Figure 2 outlines the approximate areas included in each survey.

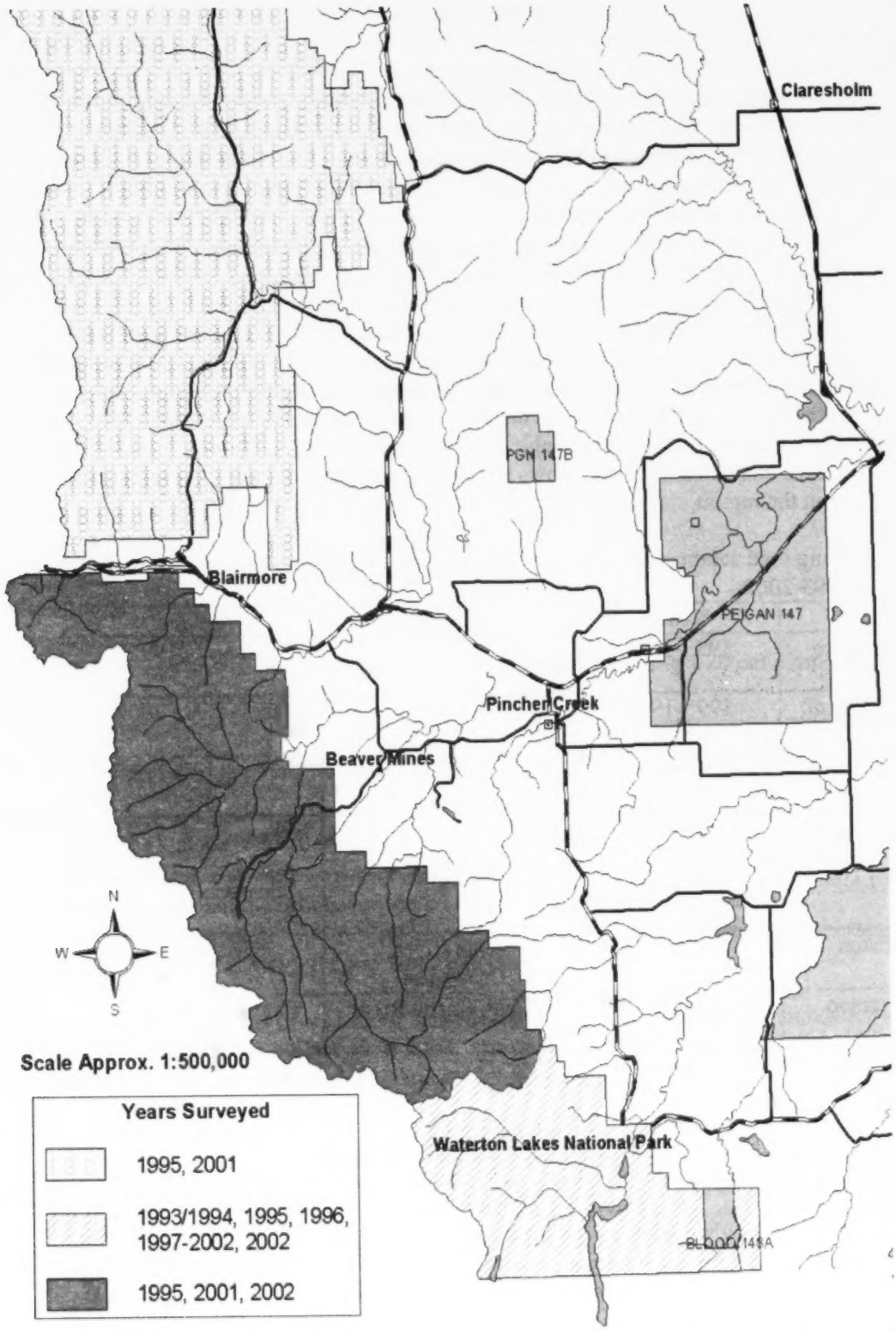

Figure 2. Approximate area and years that long-toed salamander surveys took place within the headwaters of the Oldman River drainage, 1993-2002.

3.0 METHODS

3.1 Distribution Data

Thirty-nine previously unsurveyed lakes and ponds were examined for presence/no detection of long-toed salamanders May through September, 2002. Efforts were concentrated in areas not previously surveyed. Presence/no detection of long-toed salamanders at each site was determined through daytime shoreline surveys for eggs and larvae, as described by Thoms *et. al.* (1997). Surveys included the entire perimeter of each site. These survey methods parallel those used in ongoing and past long-toed salamander monitoring programs in the region (Paton, 2002; Pearson, 2001).

Long-toed salamander, western toad (*Bufo boreas*), Columbia spotted frog (*Rana luteiventris*), striped chorus frog (*Pseudacris triseriata*) and tiger salamander (*Ambystoma tigrinum*) occurrence data collected during all seven recorded surveys within the Oldman River drainage were derived from a series of related reports and entered into a database. Long-toed salamander distribution data were amalgamated and mapped using a Geographic Information System (ArcView). Table 1 lists general survey locations and dates. Figure 2 shows the approximate area covered by each survey that has taken place in the region.

Table 1. Long-toed salamander surveys within the Oldman River drainage, 1993-2002.

Survey	Years	Locations	*Reference*
Fukumoto	1993-1994	WLNP	Fukumoto, 1995
Wallis *et. al.*	1995-1996	WLNP	Wallis *et. al.*, 2002
Oseen *et. al.*	<1995	WLNP, Castle River, Crowsnest	Oseen *et. al.*, 1995
Nelson *et. al.*	1995	WLNP, Castle River, Crowsnest	Nelson *et. al.*, 1995
WLNP	1997-2002	WLNP	Pearson, 2001
Paton	2001	Castle River, Crowsnest	Paton, 2002
Pearson	2002	WLNP, Castle River	Pearson, unpubl. data

WLNP = Waterton Lakes National Park

3.2 Long-toed Salamander Habitat Associations

Some reports on long-toed salamanders in Alberta have included anecdotal evidence of the species' habitat preferences (Fukumoto, 1995; Paton, 2002). Huynh *et. al.* (2002) reported that all surveyed long-toed salamander breeding wetlands in Athabasca and Kananaskis Valleys lacked fish. Paton (2001) recommended that the effects of fish on long-toed salamanders be researched in southwest Alberta. A goal of this study is to evaluate whether previously-identified and additional habitat preferences of the long-toed salamander in southwest Alberta can be confirmed through statistical investigation.

Forty-two study sites located in the Waterton and Castle River drainages were visited between 30 May and 15 September, 2002. A suite of 17 aquatic and riparian habitat characteristics (listed and briefly described below) were measured at randomly-chosen points on the north, south, east and west shores of each study site (four replicates per site). All characteristics were measured at 27 of the sites visited in 2002. A limited number of characteristics (*) were measured at the other 15 sites surveyed in 2002. An additional 16 sites were surveyed only for presence/no detection of amphibians, trout and minnows in 2001.

General

- Presence/no detection of long-toed salamanders (visual shoreline survey) *
- Presence/no detection of other amphibian species (visual shoreline survey)*
- Presence/no detection of trout species (stocking records, visual shoreline survey) *
- Presence/no detection of minnow species (visual shoreline survey) *
- Beaver activity (historical, current, none evident) (visual survey) *

Aquatic

- Waterbody size (ha) *
- Maximum depth (m) *
- Water temperature 1 m from shoreline (°C)
- Water depth 1 m from shoreline (cm)
- Aquatic substrate (% cover in a 1 m^2 area)
- Emergent aquatic vegetation type (grass, sedge, rush)
- Density and diversity of zooplankton (samples collected using a 20 cm diameter zooplankton tow net 5 m from shore, analyzed in laboratory)
- Density and diversity of macroinvertebrates (1 minute sampling period using a 1 mm mesh net)

Riparian

- Slope (%) (slope immediately adjacent to shoreline sampled using a clinometre)
- Distance from shoreline to nearest forest cover (m)
- Degree of human disturbance evident (none, light, moderate, severe)
- Percent cover of shrub species, rock and woody debris 5 m and 50 m from shoreline (within two, random 1 m^2 areas per 5 m and 50 m point)

Multiple regression analysis of all habitat variables and long-toed salamander abundance will be completed after further data collection in 2003. The analysis will examine long-toed salamander associations with selected habitat characteristics.

3.3 Pond Experiment

Although little controversy exists regarding the effects of certain fish predators on some amphibians, there is little agreement on the precise mechanisms involved. The use of experimental ponds to evaluate variation in amphibian life histories due to predation and competition is well-established (Figiel, Jr. and Semlitsch, 1990; Tyler *et. al.*, 1998b). The effects of three predators (one rainbow trout fry (*Onchorhynchus mykiss*), two fathead minnows (*Pimephales promelas*), two dragonfly larvae (*Aeshna* sp.)) versus predator-free environments on the survival and growth rate of larval long-toed salamanders were evaluated in a series of 1200 L plastic tanks (four replicates of each treatment) located within a fenced enclosure at the University of Lethbridge.

Salamander larvae originated from approximately 700 eggs collected from three adjacent fishless ponds located 6 km southwest of Beaver Mines, Alberta (49°27'N, 114° 12'W) on 30 May, 2002. In brief, the ponds had previously (17 May, 2002) been filled with 1150 L of irrigation water, 800 g of air-dried reeds (*Typha*) and 200 g of dried leaf material, both of which were collected from the edges of a local pond. One litre innoculations of concentrated zooplankton collected from 3-6 local ponds commenced on 14 June and continued every 14-16 days until the end of the experiment. Zooplankton innoculations were aimed at providing an *ad-libitum* food source for the salamander larvae and to minimize intraspecific cannibalism (Wildy *et al.*, 2001).

Predator treatments were assigned to the 16 tanks at random. The predators were added to the tanks on 28 June, allowing the larval salamanders (40 individuals per pond) a 7-day acclimation period in the absence of fish and dragonfly larvae. The experiment was concluded on 28 July, at the first indication of gill resorption. The survival of all individuals was evaluated as each tank was drained; after which each individual was weighed (± 0.001 g).

4.0 RESULTS

4.1 Distribution Data

Long-toed salamanders were detected at 68 of the approximately 135 sites surveyed 1993-2002, at elevations from 1275 m to 2018 m. Appendix A includes coded observation data for each site, including the year that long-toed salamanders were last detected at each location. Thirteen previously unrecorded long-toed salamander breeding locations were documented in 2002 (K. Pearson, unpubl. data). Long-toed salamander presence/no detection data for the region are presented in Figure 3. Site-specific information is considered sensitive and is not included in this report. Site location data is stored with the Regional Endangered Species Biologist, Lethbridge.

4.2 Long-toed Salamander Habitat Associations

Selected habitat measurements observed at each of the 27 sites sampled in 2002 are included in Appendix A. Regression analysis of that data is ongoing and the results will be available in Autumn, 2003.

Trout/minnows and long-toed salamanders generally did not co-exist in wetlands in the Castle and Waterton River drainages in 2001-2002. Of the 31 wetlands where long-toed salamanders were observed, 100% lacked trout and 94% lacked minnows. Table 2 summarizes the number of locations where long-toed salamanders were present in relation to fish, based on 2001/2002 field surveys. Figure 4 provides a spatial representation of the data in Table 2.

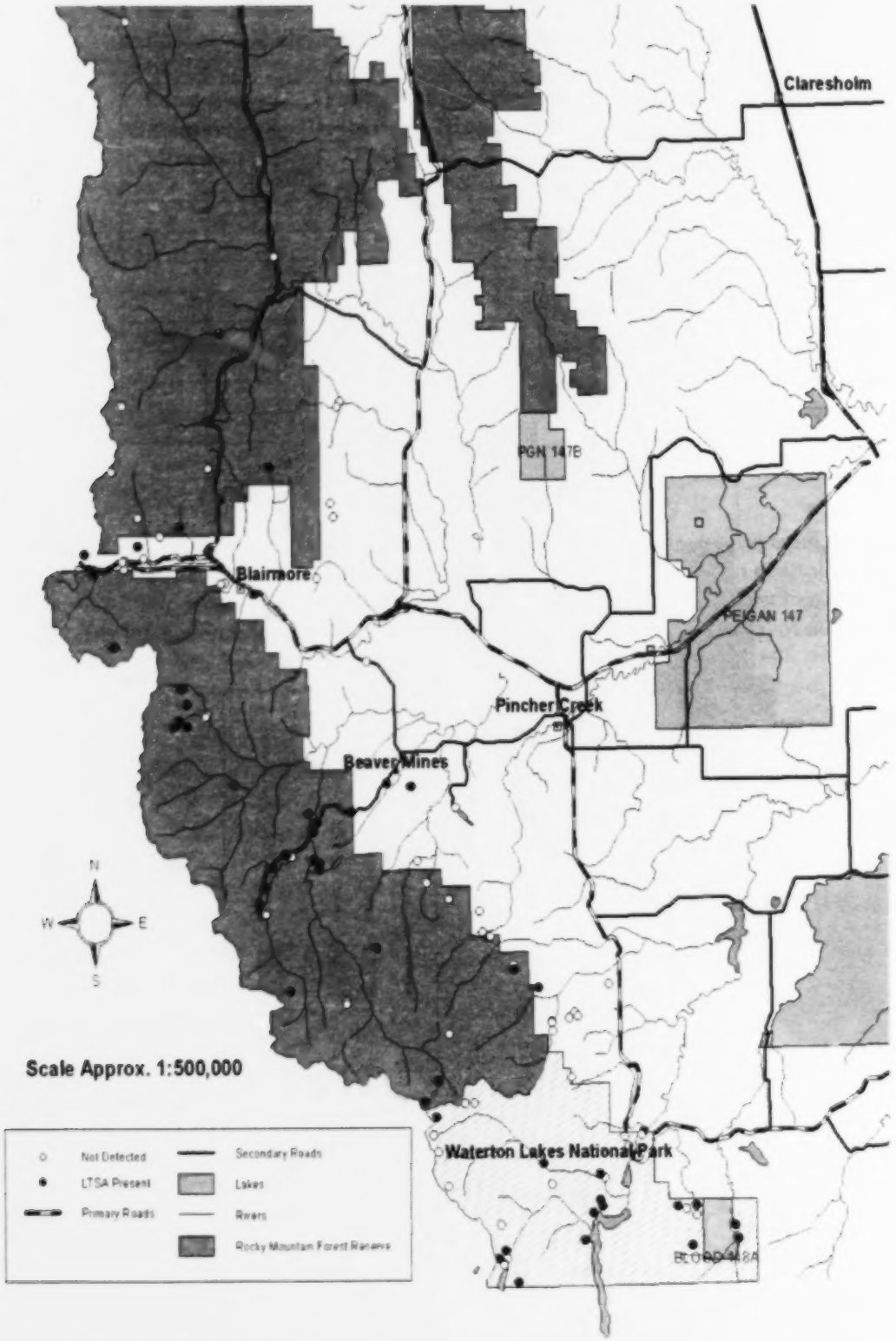

Figure 3. The distribution of long-toed salamanders in the headwaters of the Oldman River drainage, 1993-2002.

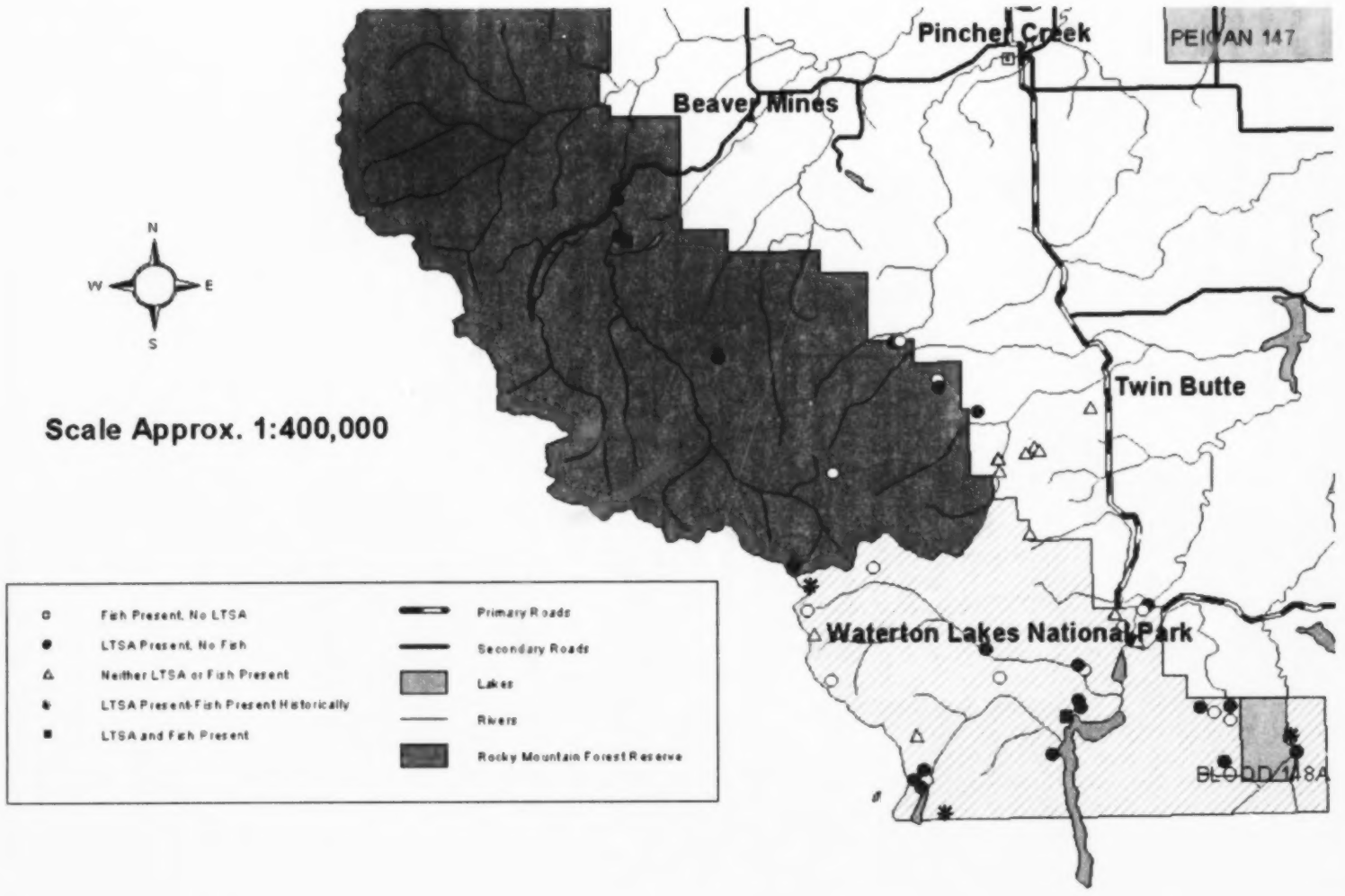

Figure 4. The relative distribution of long-toed salamanders and fish species (trout and/or minnows) in the Waterton and Castle River drainages, 2001/2002.

Table 2. Number of sites where long-toed salamanders, trout and minnows were observed in the Waterton and Castle River drainages, 2001-2002.

Long-toed Salamander Present	Trout Present	Trout Present Historically	Minnows Present	# Sites
X	-	-	-	26
X	X	-	-	0
-	X	-	-	10
X	-	X	-	3
X	-	-	X	2
-	X	-	X	6
X	X	-	X	0
-	-	-	-	11
			Total	58

4.3 Pond Experiment

On average, fewer than 10% of larval salamanders survived 30 days in the trout and minnow ponds (Figure 5; $F_{3,15}$ =9.758, P = 0.002), whereas between 25-60% of the larvae in control and dragonfly ponds survived. Exposure to minnows reduced the mass of larvae by 34-50% compared to larvae from the other three environments (Figure 6; $F_{3,15}$ = 5.574, P = 0.012). Survival of all predators was 100%.

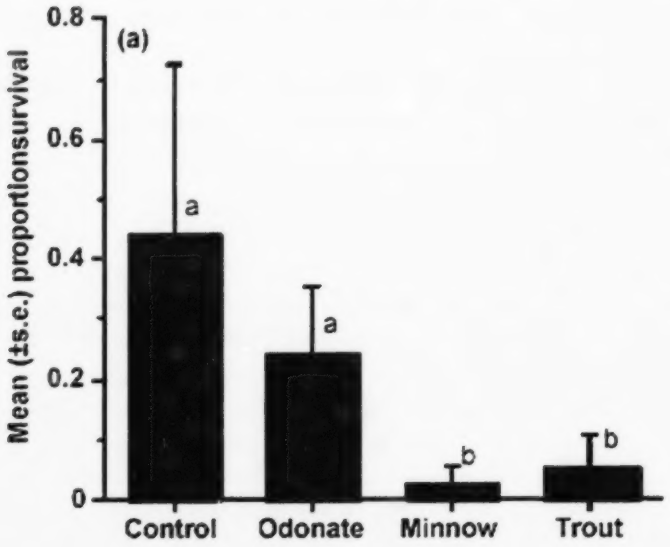

Figure 5. Mean (± s.e.) proportion survival of larval long-toed salamanders reared for 8 weeks in experimental ponds containing dragonfly larvae, minnows, and trout. Pairs of means are significantly different if they do not have the same lower-case letters above the bars.

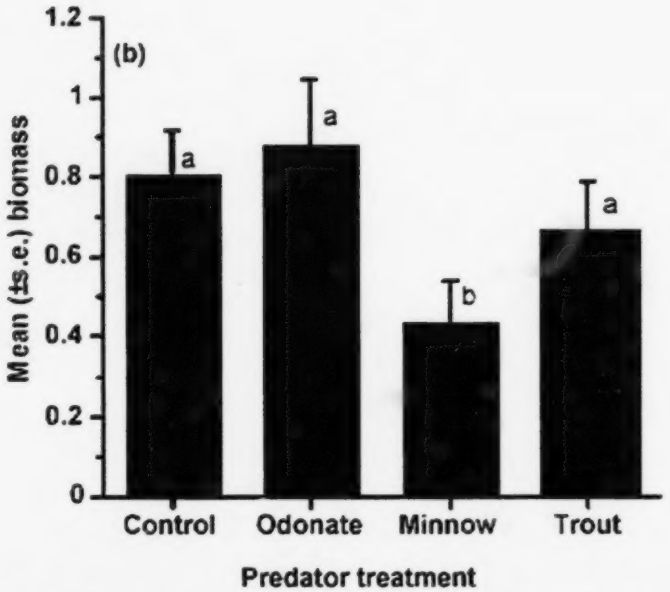

Figure 6. Mean (± s.e.) biomass of larval long-toed salamanders reared for 8 weeks in experimental ponds containing dragonfly larvae, minnows, and trout. Pairs of means are significantly different if they do not have the same lower-case letters above the bars.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Distribution Data

To date, no long-toed salamander populations have been identified north of Highway 517 to the Highwood Pass area of Kananaskis Country (Paton, 2001; Rose, 2003). The possibility of continuous distribution between the Crowsnest Pass and Kananaskis Country breeding areas, identified by Powell *et. al.* (1997), has not been thoroughly investigated. Long-toed salamander survey effort in the area north of Highway 517 to Kananaskis Country should be intensified.

Inter-provincial and international collaboration with agencies responsible for long-toed salamander management in British Columbian and Montana should be continued and strengthened. Management and monitoring of widely-distributed amphibians such as the long-toed salamander should be undertaken on an ecosystem scale.

As shown by Paton (2002), long-toed salamanders have not been recently detected at numerous sites where they were observed in other surveys during the past ten years. This may be a result of a number of factors such as climate, pollution, disease, flooding, habitat alteration, or the interaction of a variety of factors. Discrepancies in timing or methods of surveys may also account for the observed variation.

Based on the unprecedented decline in amphibian populations observed globally since the 1970's, consistent, long-term monitoring of amphibian populations as well as environmental indicators (i.e, pH, water temperature, pollution levels) in the region is imperative to effective management of amphibian populations. Fukumoto (1995) showed that pH levels of 7 lakes and ponds in Waterton Lakes National Park had decreased by an average of approximately pH 2.25 since 1971. Such acidic conditions have been shown to cause egg mortality in spotted salamanders (Pough, 1976), and other detrimental effects on long-toed salamanders may exist. Given predictions of global climate change (Schindler, 2001), water temperature is another important environmental indicator that should be closely monitored. Numerous studies have documented persistent, unnatural levels of organochlorines and trace metals in subalpine lakes in Banff National Park (Campbell *et. al.*, 2000). Intermittent monitoring of toxic compounds in selected water bodies throughout the headwaters of the Oldman River drainage should be undertaken to provide baseline information regarding their potential impacts on amphibians.

5.2 Long-toed Salamander Habitat Associations

As has been observed in Montana by Funk and Dunlap (1999), in Washington State by Tyler *et. al.* (1998), and in Idaho by Pilliod and Petersen (2001), long-toed salamanders do not appear to co-exist with trout in southwest Alberta. Direct trout predation on salamander larvae is likely the mechanism responsible for the observed exclusion of salamanders from some aquatic habitats (K. Pearson, unpubl. observ.; Tyler *et. al.* 1998b), while other trout-inhabited waterbodies may be generally unsuitable for breeding salamanders. Of the 15 waterbodies where non-native trout were observed, they were introduced by stocking in 13 locations, and via flooding in the other two locations.

In the interest of ecosystem integrity, specifically amphibian management, fish and wildlife managers should seriously consider cessation of fish stocking in lakes that are likely former long-toed salamander habitats. Lakes with self-perpetuating, introduced fish populations should undergo systematic removal of fish (Parker and Schindler, 2000). Costly long-toed salamander reintroduction programs would not likely be necessary at most sites, as long-toed salamanders have been known to recolonize aquatic habitats from which they were extirpated due to fish stocking (Funk and Dunlap,

1999). Long-toed salamanders were likely extirpated as a result of past trout stocking in three lakes located in Waterton Lakes National Park (Figure 4). If such extirpations did take place, salamanders have successfully re-colonized those lakes since their fish populations were winterkilled. This is a likely scenario, as all three of the re-colonized lakes are located within three kilometres of historically fishless wetlands that also host breeding salamander populations.

It should be ensured that bullfrogs (*Rana catesbiana*) are not permitted to colonize Alberta. Studies in California and British Columbia showed that bullfrog population increases were correlated with declines in native frog species (Kiesecker and Blaustein, 1998; Price, 1998). Introduced from Eastern North America circa 1940, the current range of bullfrogs includes the lower mainland and southern Okanagan regions of British Columbia as well as the Bitterroot Mountains of Montana (Price, 1998).

Similarly, the presence of all non-native fishes such as smallmouth bass (*Micopterus dolomieui*) and goldfish (*Carassius auratus*) should be closely monitored and controlled. Both of the above-noted species have been shown to negatively affect amphibian species (Kiesecker and Blaustein, 1998; Monello and Wright, 2001).

Results of the ongoing habitat association analysis may be applied by wildlife and aquatic system managers in determining habitats likely occupied by long-toed salamander prior to fish stocking. This information may also facilitate identification of locations in which aquatic ecosystem restoration would benefit native amphibians.

5.3 Pond Experiment

The results of our 2002 experiment indicate that minnows have the potential to cause just as great, or greater, a reduction in salamander growth and survival as better-known predators such as trout. This indicates that indirect effects, presumably involving competition for limited zooplankton prey, have the potential to play an important role in causing fish-induced reductions in salamander growth and survival.

In 2002, minnow species and long-toed salamanders were observed within the same water body in two locations, whereas both minnows and trout were observed at six locations where long-toed salamanders were not detected. Though flooding of rivers into amphibian breeding ponds is likely responsible for some minnow introductions, minnows may be introduced (directly or indirectly) to other locations as bait fish (Pearson, unpubl. observ.). Minnow-specific surveys were not conducted in 2002. Rather, minnows were simply noted upon their observation, so there are likely additional locations where minnows were not observed. In 2003, more rigorous minnow surveys are planned to determine the extent to which they may cause conservation implications for amphibians such as the long-toed salamander.

Possession and use of live bait fish has been restricted in the Bow-Crow Forest Reserve since prior to 1975. The challenging task of bait fish restriction enforcement should be continued throughout Alberta. The presence of introduced bait fishes in ponds and lakes should be monitored and they should be removed as much as possible.

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Appendix A. Summary of sites surveyed for presence (1) and no detection (0) of long-toed salamander (LTSA), western toad (WETO), Columbia spotted frog (SPFR), tiger salamander (TISA), trout species, and minnow species at southwest Alberta survey sites, 1993-2002. 'H' represents a site where fish are known or highly likely to have existed historically, but evidence has not been observed recently. Waterbody size and depth, and average temperature and depth 1 m from shoreline are included for the twenty-seven sites where habitat measurements were collected in 2002.

Site #	Elev. (m)	Years Surveyed	Year LTSA Last Detected	LTSA	WETO	SPFR	SCFR	TISA	Trout	Minnow	Size (ha)	Max. Depth (m)	Av. T (°C)	Av. Shoreline Depth (cm)
1	1695	2002	-	0	1	1	0	0	1	0	4.65	5	17.5	11.45
2	1520	2002	-	0	0	0	0	0	1	0	4.53	15.5	15.4	19.88
3	6759	2002	-	0	0	0	0	0	1	0	10.9	32	6.7	32.5
4	1934	2002	-	0	0	0	0	0	1	0	6.44	13	13	30.75
5	2027	2002	-	0	0	0	0	0	1	0	2.53	13	10.9	26.75
6	1334	2002	2002	1	1	0	0	0	0	0	0.56	1	19.5	15.5
7	1931	1994, 1997-2002	2002	1	0	1	0	0	H	0	2.03	2	14	14
8	1877	1994, 2000-2002	2002	1	1	0	0	0	H	0	1.57	12	11.5	18.9
9	1806	2002	2002	1	0	1	0	0	0	0	0.14	1.5	18.75	10.63
10	1774	2002	2002	1	0	0	0	0	0	0	1	2	9.25	37
11	1555	2002	2002	1	1	1	1	0	0	0	0.06	1.5	19	10.6
12	2000	2002	-	0	0	0	0	0	H	0	2.35	9.3	14.4	22.6
13	1571	2002	2002	1	0	0	0	0	0	0	0.03	0.71	17.9	24.5

14	1368	2002	-	0	0	0	0	0	1	1	0.06	0.4	12.3	20
Site #	**Elev. (m)**	**Years Surveyed**	**Year LTSA Last Detected**	**LTSA**	**WETO**	**SPFR**	**SCFR**	**TISA**	**Trout**	**Minnow**	**Size (ha)**	**Max. Depth (m)**	**Av. T (°C)**	**Av. Shoreline Depth (cm)**
15	1389	2002	2002	1	0	0	0	0	0	0	0.15	0.5	14.4	21.8
16	1287	1994, 1997-2002	2002	1	1	1	0	1	H	1	3.52	5.5	16.4	21.5
17	1671	1995-2002	2002	1	0	1	0	0	0	0	0.01	1	11.6	16.7
18	1338	1997-2002	-	0	0	0	0	0	0	0	0.03	1	14.9	11.5
19	1418	1994, 1997-2002	2002	1	1	1	0	0	0	0	0.1	1	16	41.25
20	1971	2002	-	0	0	0	0	0	H	0	1.97	8	10.9	30.3
21	1482	2002	-	0	0	0	1	0	0	0	0.45	2	13	24.3
22	2018	2002	2002	1	1	1	0	0	0	0	0.18	0.5	14.4	8.3
23	1547	2002	-	0	1	1	0	0	1	1	0.4	5	18.3	16.4
24	1438	2001, 2002	2002	1	1	0	0	0	0	0	0.02	0.03	18	12.1
25	1585	2002	2002	1	0	0	0	0	0	0	0.018	1	21.3	24.3
26	1574	2002	2002	1	0	0	0	0	0	0	0.006	0.14	26	12.8
27	1578	2002	-	0	1	1	0	0	1	0	2.5	5	21.4	41
28	1356	2002	-	0	0	0	1	0	0	0	-	-	-	-
29	1465	2002	-	0	0	0	2	0	0	0	-	-	-	-

30	1471	2002	-	0	1	1	0	1	0	0	-	-	-	-
31	1482	2002	-	0	0	0	0	0	0	0	-	-	-	-
Site #	**Elev. (m)**	**Years Surveyed**	**Year LTSA Last Detected**	**LTSA**	**WETO**	**SPFR**	**SCFR**	**TISA**	**Trout**	**Minnow**	**Size (ha)**	**Max. Depth (m)**	**Av. T (°C)**	**Av. Shoreline Depth (cm)**
32	1615	2002	2002	1	0	1	0	0	0	0	-	-	-	-
33	1417	2002	2002	1	0	1	0	0	0	0	-	-	-	-
34	1370	2001, 2002	2002	1	1	1	0	0	0	0	-	-	-	-
35	1370	2002	2002	1	1	0	0	0	0	0	-	-	-	-
36	1443	2001, 2002	2002	1	1	1	0	0	0	1	-	-	-	-
37	1482	2002	-	0	0	1	0	1	0	0	-	-	-	-
38	1482	2002	-	0	0	1	1	0	0	0	-	-	-	-
39	1522	2002	2002	1	0	0	0	0	0	0	-	-	-	-
40	1386	2002	-	0	0	0	0	0	1	1	-	-	-	-
41	1302	2002	2002	1	0	0	0	0	0	0	-	-	-	-
42	1302	2002	-	0	0	0	0	0	1	0	-	-	-	-
43	1300	1997-2002	2002	1	1	0	1	1	0	0	-	-	-	-
44	1330	1994, 1996-2002	2002	1	1	1	0	0	H	0	-	-	-	-
45	1330	1994, 1996-2002	-	0	1	1	0	0	1	0	-	-	-	-

46	1330	1994, 1996-2002	2001	1	1	1	0	0	0	0	-	-	-	-
47	1300	1994, 1997-2002	2001	1	1	0	1	1	0	0	-	-	-	-
48	1380	1996-2002	2002	1	1	1	0	0	H	0	-	-	-	-
Site #	**Elev. (m)**	**Years Surveyed**	**Year LTSA Last Detected**	**LTSA**	**WETO**	**SPFR**	**SCFR**	**TISA**	**Trout**	**Minnow**	**Size (ha)**	**Max. Depth (m)**	**Av. T (°C)**	**Av. Shoreline Depth (cm)**
49	1700	1996-2002	1999	1	1	1	0	0	0	0	-	-	-	-
50	1375	1994, 1996-2002	1994	1	1	1	1	1	0	0	-	-	-	-
51	1325	1994, 1997-2002	1994	1	1	1	1	1	0	0	-	-	-	-
52	1950	2001	-	0	1	0	0	0	0	0	-	-	-	-
53	1300	1997-2002	-	0	0	0	1	0	0	0	-	-	-	-
54	1280	1997-2002	-	0	0	0	1	0	H	H	-	-	-	-
55	1500	1997-2002	-	0	1	1	0	0	H	H	-	-	-	-
56	1500	1997-2002	-	0	1	1	0	0	H	H	-	-	-	-
57	1525	1994	-	0	0	0	1	0	0	0	-	-	-	-
58	1850	1996, 1997-2002	1999	1	0	1	0	0	0	0	-	-	-	-
59	1388	1995, 2001	1995	1	0	0	-	0	-	-	-	-	-	-
60	1674	1995, 2001	2001	1	1	1	-	0	-	-	-	-	-	-
61	1755	1995, 2001	2001	1	0	1	-	0	-	-	-	-	-	-

62	1395	1995, 2001	1995	1	0	0	-	0	-	-	-	-	-	-
63	1275	1995, 2001	2001	1	0	0	-	1	-	-	-	-	-	-
64	1275	1995, 2001	2001	1	0	0	-	0	-	-	-	-	-	-
65	1275	1995, 2001	1995	1	0	0	-	0	-	-	-	-	-	-
Site #	**Elev. (m)**	**Years Surveyed**	**Year LTSA Last Detected**	**LTSA**	**WETO**	**SPFR**	**SCFR**	**TISA**	**Trout**	**Minnow**	**Size (ha)**	**Max. Depth (m)**	**Av. T (°C)**	**Av. Shoreline Depth (cm)**
66	1388	1995, 2001	1995	1	0	0	-	0	-	-	-	-	-	-
67	1344	1995, 2001	-	0	0	1	-	0	-	-	-	-	-	-
68	1335	1995, 2001	1995	1	0	0	-	0	-	-	-	-	-	-
69	1410	1995, 2001	2001	1	0	0	-	0	-	-	-	-	-	-
70	1395	1995, 2001	1995	1	0	0	-	0	-	-	-	-	-	-
71	1343	1995, 2001	1995	1	0	1	-	0	-	-	-	-	-	-
72	1395	1995, 2001	2001	1	1	1	-	0	-	-	-	-	-	-
73	1397	1995, 2001	1995	1	1	1	-	0	-	-	-	-	-	-
74	1328	1995, 2001	1995	1	0	0	-	0	-	-	-	-	-	-
75	1388	1995, 2001	1995	1	1	0	-	0	-	-	-	-	-	-
76	1350	1995, 2001	-	0	0	0	-	0	-	-	-	-	-	-
77	1365	1995, 2001	2001	1	0	0	-	0	-	-	-	-	-	-

78	1373	1995, 2001	2001	1	1	1	-	0	-	-	-	-	-	-
79	1374	1995, 2001	-	0	0	0	-	0	-	-	-	-	-	-
80	1905	1995, 2001	1992	1	0	0	-	0	-	-	-	-	-	-
81	1650	1995, 2001	2001	1	1	0	-	0	-	-	-	-	-	-
82	1680	1995	1995	0	0	0	-	0	-	-	-	-	-	-
Site #	**Elev. (m)**	**Years Surveyed**	**Year LTSA Last Detected**	**LTSA**	**WETO**	**SPFR**	**SCFR**	**TISA**	**Trout**	**Minnow**	**Size (ha)**	**Max. Depth (m)**	**Av. T (°C)**	**Av. Shoreline Depth (cm)**
83	-	1995	1995	0	0	1	-	0	-	-	-	-	-	-
84	-	1995	1995	0	0	0	-	0	-	-	-	-	-	-
85	-	1995	1995	0	1	0	-	0	-	-	-	-	-	-
86	-	1995	1995	0	1	0	-	0	-	-	-	-	-	-
87	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
88	-	2001	-	0	0	1	-	0	-	-	-	-	-	-
89	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
90	-	2001	2001	1	0	1	-	0	-	-	-	-	-	-
91	-	2001	-	0	1	0	-	0	-	-	-	-	-	-
92	-	2001	-	0	0	1	-	0	-	-	-	-	-	-
93	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-

94	-	2001	-	0	1	1	-	0	-	-	-	-	-	-
95	-	2001	-	0	1	0	-	0	-	-	-	-	-	-
96	-	2001	2001	1	0	1	-	0	-	-	-	-	-	-
97	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
98	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
99	-	2001	-	0	0	1	-	0	-	-	-	-	-	-
Site #	**Elev. (m)**	**Years Surveyed**	**Year LTSA Last Detected**	**LTSA**	**WETO**	**SPFR**	**SCFR**	**TISA**	**Trout**	**Minnow**	**Size (ha)**	**Max. Depth (m)**	**Av. T (°C)**	**Av. Shoreline Depth (cm)**
100	-	2001	2001	1	0	1	-	0	-	-	-	-	-	-
101	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
102	-	2001	2001	1	1	1	-	0	-	-	-	-	-	-
103	-	2001	-	0	1	0	-	0	-	-	-	-	-	-
104	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
105	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
106	-	2001	-	0	1	1	-	0	-	-	-	-	-	-
107	-	2001	-	0	0	1	-	0	-	-	-	-	-	-
108	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
109	-	2001	-	0	0	0	-	1	-	-	-	-	-	-

110	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
111	-	2001	-	0	1	0	-	0	-	-	-	-	-	-
112	-	2001	-	0	1	0	-	0	-	-	-	-	-	-
113	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
114	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
115	-	2001	2001	1	0	0	-	0	-	-	-	-	-	-
116	-	2001	-	0	1	1	-	0	-	-	-	-	-	-
Site #	**Elev. (m)**	**Years Surveyed**	**Year LTSA Last Detected**	**LTSA**	**WETO**	**SPFR**	**SCFR**	**TISA**	**Trout**	**Minnow**	**Size (ha)**	**Max. Depth (m)**	**Av. T (°C)**	**Av. Shoreline Depth (cm)**
117	-	2001	-	0	0	0	0	0	-	-	-	-	-	-
118	-	2001	-	0	0	0	0	0	-	-	-	-	-	-
119	-	2001	-	0	0	0	0	0	-	-	-	-	-	-
120	-	2001	--	0	0	0	0	0	-	-	-	-	-	-
121	-	2001	-	0	0	0	0	0	-	-	-	-	-	-
122	-	2001	-	0	0	0	0	0	-	-	-	-	-	-
123	-	2001	-	0	0	0	0	0	-	-	-	-	-	-
124	-	2001	-	0	0	0	0	0	-	-	-	-	-	-
125	-	2001	-	0	0	0	0	0	-	-	-	-	-	-